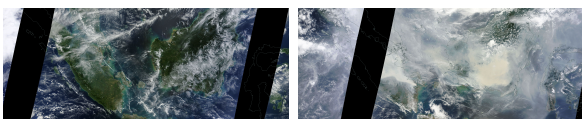


GPM characterization of Indonesian fire danger during the severe 2015 fire season

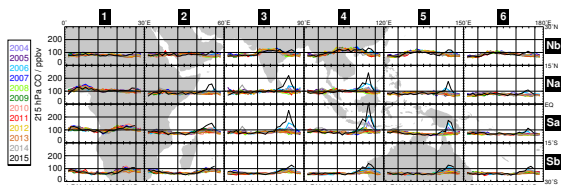
Robert Field, NASA GISS / Columbia University

The 2015 fire season in Indonesia

Fire in Indonesia is used to clear and manage land for agriculture and plantation forestry, often on drained peat swamps in Sumatra and Kalimantan (Indonesian Borneo) (1). Under sufficiently dry conditions – usually associated with El Niño – fires on the surface escape underground into the peat. There, the fires have an inexhaustible supply of fuel and cannot be extinguished; until the return of the monsoon, the peat fires burn continuously, creating severe air quality problems in western Indonesia, Malaysia, Singapore and Thailand. During the severe burning of September and October 2015, CO₂-equivalent GHG emissions were 1.5 billion metric tons, between the annual mean fossil fuel emissions of Japan and India (2,3).



True color MODIS scenes over Sumatra and Kalimantan for June 17, 2015 before significant burning (left), and for October 19, 2015 at the peak of the fire season (right).



Biweekly, regional, upper tropospheric (215 hPa) carbon monoxide (CO) from the Aura Microwave Limb Sounder (MLS) for each year between 2004 and 2015. The 2015 CO (black) represents the biggest enhancement during the MLS mission, when a plume of CO stretched half way around the world at the equator (3).

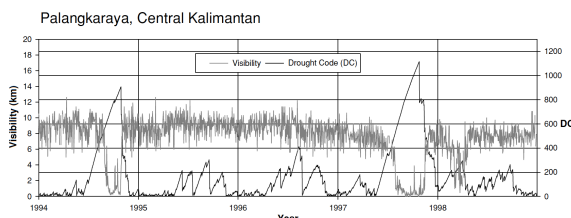


Indonesian military personnel fighting a peat fire to the southeast of Palangkaraya, Central Kalimantan (October 19, 2015, credit: David Gaveau, CIFOR).

Monitoring fire danger

As part of an evolving fire management program, the Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG) operates the Fire Weather Index system, used to identify conditions under which fires can start and spread underground into peat (4).

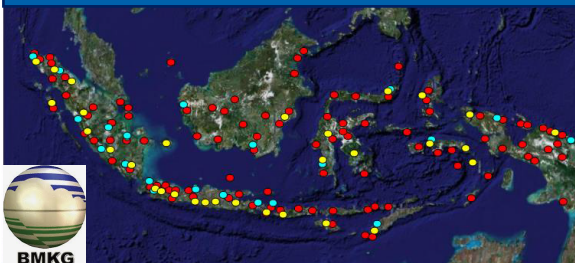
The Drought Code (DC) component of the system is used to identify regions where it is sufficiently dry for peat to burn. The DC is a simple moisture balance model computed daily from 12:00 2m air temperature and 24-hour total precipitation. This is the main tool used by Indonesian authorities to distinguish between normal and dangerously dry conditions.



Higher DC values indicate drier conditions. There is a DC threshold of ~350 below which the peat remains too wet to burn, and above which fires lit on the surface can escape underground. During the 1990s, this occurred in 1994 and 1997, which can be seen by the significant reductions in horizontal visibility (4), but not otherwise.

Data limitations

A current limitation of the system is simply the sparse network of GTS-level synoptic weather stations in the fire-prone regions of Sumatra and Kalimantan. Fire weather in remote regions is often estimated from a single weather station 100's of kilometers away. This limits the ability of fire-fighting agencies to prioritize prevention activities and fire suppression measures.

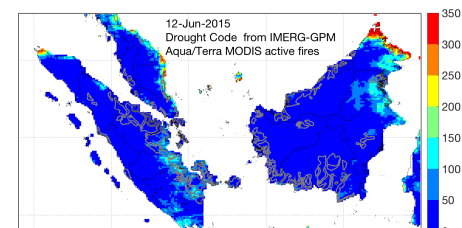


● Stasiun Meteorologi (120) ● Stasiun Geofisika (31) ● Stasiun Klimatologi (21)

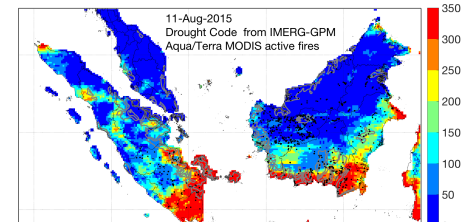
GPM-based fire danger

We are now using GPM-IMERG precipitation estimates of daily total precipitation as part of the Global Fire Weather Database, alongside six other precipitation estimates (5). The maps below show the DC computed from the GPM_3IMERGDF.03 estimate through the evolution of the 2015 fire season, along with MODIS active fire detections from Aqua and Terra. Peat deposits are shown by the grey contours.

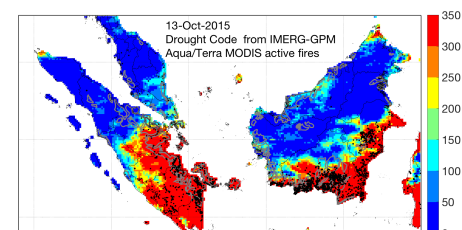
June 12: At the start of the dry season, there are scattered fires, but the DC is too low to sustain widespread fire activity, or large, deep burning peat fires. Conditions are also too wet for surface fires.



August 11: Several months into the dry season, fire activity has increased, but primarily in non-peat areas or peat that is too wet to burn. There is no regional pollution enhancement at this point.



October 13: At the height of the fire season, large peat fires are widespread across southern Sumatra and Kalimantan. Fires located on peat with high GPM-based DC are those which produce the bulk of the regional haze.



GFWD availability

All data are freely available from the Global Fire Weather Database website:

<http://data.giss.nasa.gov/impacts/gfwd/>

References

1. Gaveau DLA, *et al.* (2014) Major atmospheric emissions from peat fires in Southeast Asia during non-drought years: evidence from the 2013 Sumatran fires. *Scientific Reports* 4.
2. Huijnen V, *et al.* (2016) Fire carbon emissions over maritime southeast Asia in 2015 largest since 1997. *Scientific Reports* 6.

3. Field RD, *et al.* (2016) Indonesian fire activity and smoke pollution in 2015 show persistent nonlinear sensitivity to El Niño-induced drought. *Proceedings of the National Academy of Sciences of the United States of America* 113(33):9204-9209.
4. de Groot WJ, Field RD, Brady MA, Roswintarti O, & Mohamad M (2007) Development of the Indonesian and Malaysian Fire Danger Rating Systems. *Mitigation and Adaptation Strategies for Global Change* 12:165-180.
5. Field RD, *et al.* (2015) Development of a Global Fire Weather Database. *Natural Hazards and Earth System Sciences* 15:1407-1423.